ORIGINAL ARTICLE

Common bacterial contaminants isolated from hospital surfaces and their antibiotic sensitivity patterns at Kampala international university teaching hospital Ishaka, Bushenyi, South-western Uganda

[1]Adan, A.A., [2]Igwe, M.C., [1,3]Pius, T, [1]Omar, S.A., [1]Salah, F.D., [1]Mahanga, S.H., [1]Mohamed, D.O., [1,3]Bushoborozi, B., [1]Mudei, M.A.

[1] Department of Medical Laboratory Science, School of Allied Health Sciences, Kampala International University, Ishaka, Uganda

[2] Department of Public Health, School of Allied Health Sciences, Kampala International University, Ishaka, Uganda

[3] Department of Pathology and Diagnostics, Kampala International University Teaching Hospital, Ishaka, Uganda

ABSTRACT

Hospital-acquired infections (HAIs) continue to be a major worldwide health issue, especially in areas with limited resources. Hospital surfaces that have been contaminated are important sources of multidrug-resistant (MDR) bacteria. A cross-sectional study was conducted at Kampala International University-Teaching Hospital to identify the patterns of antibiotic susceptibility of bacterial contamination. In six hospital rooms and departments, 112 surface swab samples were taken from high-contact objects like wheelchairs, trolleys, surgical tables, beds, and doctor's tables. To isolate and identify the bacterium, standard microbiological methods were employed. The Kirby-Bauer disk diffusion method was used to test for antimicrobial susceptibility, and the Clinical and Laboratory Standards Institute (CLSI) guidelines were used to evaluate the diameter of zones of inhibition. IBM SPSS Statistics Version 25 was used to analyze the data. Bacterial contamination was detected in 41.1% (46/112) of samples. The most commonly isolated species was Staphylococcus aureus 59.6% (28/47), followed by Escherichia coli 10.6% (5/47), Bacillus species 10.6% (5/47), Coagulase Negative Staphylococcus 8.5% (4/47), Pseudomonas aeruginosa 6.4% (3/47), Klebsiella species 2.1% (1/47) and Enterobacter species 2.1% (1/47). Methicillin resistance was alarmingly present in 85% of Staphylococcus aureus samples, while high resistance to Clindamycin 92.8% (26/28) and Imipenem 89.3% (25/28) was also observed. Amikacin showed the highest efficacy 95.3% (23/28) against Staphylococcus aureus. Overall, Amikacin exhibited the highest efficacy against all tested bacterial isolates, whereas Clindamycin, Methicillin, Ceftriaxone, and Gentamicin showed the lowest activity across multiple bacterial species. Hospital surfaces harbor multidrug-resistant bacteria, with Staphylococcus aureus being the most prevalent. Strict infection control measures are necessary, as evidenced by the high rates of resistance Amikacin exhibited the highest efficacy, suggesting its potential role in empirical treatment. Enhanced antimicrobial stewardship and targeted interventions in high-risk wards are crucial to reducing nosocomial infections.

Keywords: Antibiotic resistance, Bacterial contamination, Nosocomial infections, Hospital surfaces, Infection control

*Corresponding Author

Abdirahman Abdullahi Adan, Department of Medical Laboratory Science, School of Allied Health Sciences, Kampala International University, Ishaka, Uganda. Email: adan.abdirahman@studwc.kiu.ac.ug ,Tel: +252616251391

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Introduction

Nosocomial infections, also known as hospital-acquired infections (HAIs), remain a significant global health issue, particularly in low- and middle-income countries (LMICs). Extended hospital stays, higher mortality rates, and a substantial financial impact on healthcare systems are all linked to these infections. Multidrug-resistant (MDR) organisms account for a significant percentage of hospital-acquired infections, which complicates treatment options and raises the risk of poor patient outcomes [1,2,3].

Bacterial cross-contamination has a major impact on the spread of resistant strains and healthcare-associated illnesses (HCAIs) [4]. Although the majority of hospital-acquired diseases are thought to be spread directly from patient to patient, there is growing evidence that infections can also be spread by medical staff and the clinical setting, including surfaces and equipment [5]. Hospital-acquired infections affect more than 1.4 million people globally at any given moment [6,7]. Regional disparities in infection prevalence are evident, with Southeast Asian institutions reporting the highest rates (11.8%) and Eastern Mediterranean (10.0%), while the lowest rates are observed in the Western Pacific (7.7%) and Europe (9.0%) [8]. In Africa, prevalence of Hospital acquired infections recorded ranged from 7.2% to 28% [9,10]. Additionally, noncompliance with infection control protocols, such as inadequate hand hygiene and improper sterilization of medical equipment, exacerbates the spread of hospital-associated infections [11].

While many studies in high-income countries have extensively explored the contamination of hospital surfaces and its contribution to Hospital-acquired diseases, particularly in Uganda and other low- and middle-income countries, comparatively little study has been done [12]. The scarcity of localized data hampers the ability of hospital administrators to implement targeted infection control and antimicrobial stewardship strategies. Reports indicate Uganda has one of the highest estimated hospital acquired infections prevalence rates in Africa (28%) [10, 13]. It therefore imperative to assess the extent of environmental contamination in its healthcare facilities.

By examining the frequency of bacterial contamination and antimicrobial resistance patterns of the bacterial pollutants on hospital items, the current study sought to close this data gap at Kampala International University Teaching Hospital to guide immediate infection control interventions.

Materials and Methods

Study Design and Study Area

This study employed a cross-sectional design and was conducted at Kampala International University Teaching Hospital (KIU-TH) located in Ishaka, Bushenyi, South Western Uganda between June and November, 2024. Samples were collected from various hospital departments and units, including Intensive Care Unit (ICU), Surgical ward, Accident and Emergency ward, Accident and Emergency theatre, Outpatient department, Maternity ward and Main theatre to evaluate the degree of bacterial contamination and the bacterial contaminants' patterns of antibiotic susceptibility on high-touch hospital surfaces.

Sampling technique

112 High-touch hospital surfaces were used to collect swab samples, including wheelchairs, physicians' tables, surgical tables, beds, trolleys, and surgical trays, in a variety of wards and units using a convenience sampling technique. 15. Samples were taken from the doctor's table, 11 from the surgical tray, 33 from the trolleys, 2 from the surgical table, 44 from the beds, and 7 from the wheelchairs. 11 samples were gathered from the emergency room and accident scene. 16 samples came from the main theatre, 13 from the intensive care unit, 28 from the surgical ward, 18 from Accident and Emergency, 23 from the maternity ward, and 3 from the outpatient department. Samples were collected only in the

morning and after disinfection of work surfaces. The health care personnel in the sampled departments were informed prior to the sampling procedure.

Sample Collection, Isolation and Identification

Sterile swabs soaked with sterile saline were used to collect samples, which were then inoculated onto MacConkey Agar and Blood Agar. The plates were aerobically incubated at 37°C for 24 to 48 hours. The isolates were identified using colony morphology, gram staining, and many standard biochemical tests (catalase, coagulase, oxidase, indole, citrate, and TSI assays).

Antibiotic Susceptibility Testing

The Kirby-Bauer disc diffusion method was used for antibiotic susceptibility testing (AST). On Mueller-Hinton agar, a bacterial suspension equal to 0.5 McFarland turbidity was made for every isolate. Next, antibiotic discs containing 30 µg of amikacin, 30 µg of ceftriaxone, 5 µg of methicillin, 30 µg of vancomycin, 2 µg of clindamycin, 5 µg of ciprofloxacin, 10 µg of gentamicin, 30 µg of amoxiclav, and 10 µg of imipenem were applied. WHO/CLSI guidelines and typical empirical therapies were used in the selection of antibiotics. Zone diameters were interpreted using the Clinical and Laboratory Standards Institute (CLSI) 2022 criteria.

Data Analysis

Data were entered into Microsoft Excel and subsequently analyzed using IBM SPSS Statistics, Version 25. Descriptive statistics were generated to summarize bacterial contamination and antibiotic susceptibility testing results.

Quality control

New batches of Blood agar and MacConkey agar were validated using known strains of *Escherichia coli* and *Streptococcus pneumoniae*. All the antibiotics discs were also quality controlled using standard strains of ATCC 2592 *Esherichia coli* and ATCC 29213 *Staphylococcus aureus*.

Ethical Considerations

Kampala International University's School of Allied Health Sciences and Medical Laboratory Science Department both evaluated and approved the study. The Kampala International University Research Ethics Committee (KIU-REC) issued ethical clearance under REC No. KIU-2024-458. Confidentiality and adherence to study methods were ensured by following all relevant ethical criteria.

Results

Table 1 Prevalence of bacterial contamination on hospital surfaces

Out of the 112 hospital material samples collected, 46 samples exhibited bacterial growth upon culture, indicating a bacterial contamination prevalence of 41.1% as illustrated in Figure 1.

Out of the 46 positive samples, 37 (78.3%) samples had only gram-positive bacteria, while 10(15.2%) samples produced only gram-negative bacteria. Regarding hospital material, the wheel chairs 5(71.4%) were the most contaminated followed by beds 21(47.7%), then Doctors table 6(40%), then surgical tray 4 (36.4%), then trolleys 10(30.3%). Surgical table showed no bacterial contamination as indicated in table 1 below.

Regarding the departments, OPD 2(66.7%) and Emergency wards 12(66.7%) were the most contaminated followed by surgical ward 15(53.6%) followed by ICU 6(46.2%) followed by Maternity 10(43.5%) then 1(9.1%) Emergency theatre. Main theater showed no bacterial contamination.

Table 2 Distribution of the identified Bacterial species among the isolates

A total of 112 isolates were obtained from the 46 positive swab samples. Gram-positive bacteria constituted the majority of the isolates, accounting for 37 out of 46 isolates (78.7%). The most frequently isolated bacterial species was Staphylococcus aureus 28(59.6%).

Table 3 Antibiotic Susceptibility Patterns of the Identified Bacterial Isolates

Overall, Amikacin exhibited the highest efficacy against all tested bacterial isolates, whereas Clindamycin, Methicillin, Ceftriaxone, and Gentamicin showed the lowest activity across multiple bacterial species.

Staphylococcus aureus was the most prevalent species and exhibited high sensitivity to Amikacin (95.3%) and Vancomycin (82.6%). Moderate sensitivity was observed for Ciprofloxacin (64.3%). However, it demonstrated notable resistance to Methicillin (85%), Clindamycin (92.8%) and Imipenem (89.3%).

Escherichia coli the second most isolated was highly sensitive to Amikacin 5(100%), and imipenem 5(100%). Moderate sensitivity to Ciprofloxacin 3(60%) and notable resistance Ceftriaxone 5(100%), Amoxiclav 2(40%) and Gentamycin 2(40%) was observed.

*Pseudomonas aeruginosa*was highly sensitive to Amikacin 3(100%), Imepenem 3(100%) and Ciprofloxacin 3(100%). High resistance to Ceftriaxone 3(100%) was observed.

Klebsiella was sensitive to Ciprofloxacin, Amikacin and Imipenem, however was resistant to Ceftriaxone.

Discussion

The results of this investigation, revealing a bacterial prevalence of 41.1% out of 112 hospital material samples, these findings are consistent with previous studies but position themselves on the higher end of the reported spectrum. A slightly higher prevalence (44.2%) was documented in a study conducted in the post-surgical ward of Kawolo General Hospital, Uganda [14]. Similar studies across Different prevalence rates have been recorded by Ugandan healthcare facilities; Jinja and Mulago hospitals reported 58.5% and 68.8%, respectively. These variations may stem from shared health facilities conditions, including infection control measures and sanitation practices**.** Beyond Uganda, 47% prevalence was reported in Nigeria [15], whereas a significantly higher rate of 85.8% was observed at Jimma University Teaching Hospital, Ethiopia [16]. In South Benin, a study conducted at university hospital of Abomey Calavi/so-ava reported a prevalence of 65% [17]. Another study carried out in Nigeria found that 67.7% of hospital surfaces in the pediatric ward at the University of Ilorin Teaching Hospital were contaminated with bacteria. [18]. These comparable prevalence rates across Uganda and Nigeria suggest that common risk factors, such as suboptimal infection control measures, inadequate cleaning protocols, and high patient turnover, contribute significantly to hospital-based bacterial contamination [19, 20, 21, 22]. These results highlight the necessity of improved infection control and sanitation practices in healthcare settings. The current study demonstrates a predominant presence of gram-positive bacteria, which accounted for 78.7% (37/47) of the isolates. Among these, Staphylococcus aureus emerged as the most frequently isolated pathogen, present in 59.6% of the isolates. This finding is consistent with multiple studies highlighting the ubiquitous nature of *Staphylococcus aureus* in hospital environments [23, 24, 25].Japanto et al. found that one of the most often reported nosocomial infections is Staphylococcus aureus [23], causing a variety of hospital-acquired diseases, such as surgical site infections and pneumonia [26]. Hammel et al, (2014) documented a 50.8% prevalence of *Staphylococcus aureus* in hospital environments in Zaria Nigeria [24], while Newman (2002) reported a slightly lower prevalence of 44% in a neonatal intensive care unit in Accra [27]. A Ugandan study recorded a higher *Staphylococcus aureus* prevalence of 75.4% [14], whereas in Nigeria and Cameroon, the bacterium accounted for 30.2% and 28.4% of hospital-based bacterial isolates, respectively [25,28]. Because *Staphylococcus aureus* is a common skin resident, it can easily spread from patients, caregivers, and medical staff to hospital surfaces [29, 30]. The persistence of *Staphylococcus aureus* in hospital environments

can be attributed to its resistance to desiccation and its ability to survive on dry surfaces for extended periods [31, 32].

In contrast, the study identified a lower prevalence of gram-negative bacteria (21.3%). The most commonly isolated gram-negative pathogens included *Pseudomonas aeruginosa* and *Escherichia coli*, which are frequently implicated in nosocomial infections. Japanto et al, (2016) recognized these pathogens as major contributors to hospital-acquired infections [23]. Similarly, Chandika et al. reported *Escherichia coli* (30.6%) and *Pseudomonas aeruginosa* (7.9%) as prevalent contaminants in hospital environments [33], similar findings that were also observed in Ethiopian hospital settings [34]. The existence of these bacteria highlights the need for strict infection control procedures and the persistence of Gram-negative infections in healthcare settings.

The antimicrobial susceptibility patterns observed in this study revealed significant resistance trends among bacterial isolates. *Staphylococcus aureus* demonstrated high resistance to Methicillin (85%), Clindamycin (92.8%), Imipenem (89.3%). However, it exhibited high sensitivity to Amikacin (95.3%), Vancomycin (82.6%). The complete resistance of *Staphylococcus aureus* to methicillin aligns with findings from Nkuwi et al, (2018) who reported *Staphylococcus aureus resistance to methicillin* at 92.1% [35]. Notably, Vancomycin remained highly effective against *Staphylococcus aureus* isolates, reinforcing its therapeutic importance. This pattern is further supported by research conducted by Garoy et al, (2019) which emphasized the global concern over rising MRSA cases [36]. Kuti et al, (2018) similarly reported Amikacin's broad-spectrum efficacy against *Pseudomonas aeruginosa*, *Enterobacter* and *Escherichia coli*[37].

The high resistance of *Staphylococcus aureus* to imipenem, and clindamycin corroborates existing literature, emphasizing the increasing threat of multidrug-resistant (MDR) nosocomial infections [38]. Shumita et al, (2017) underscored the necessity of prudent antibiotic stewardship by documenting substantial resistance to commonly used antibiotics [39]. Gram-negative isolates in this study exhibited strong sensitivity to Amikacin, whereas Methicillin, Clindamycin, Ceftriaxone, and Gentamicin demonstratedsignificant inactivity. This aligns with existing research highlighting growing resistance trends among nosocomial pathogens [39]. Abban et al, (2023) reported increasing aminoglycoside resistance among hospital-acquired infections [40], highlighting the critical need for efficient antimicrobial surveillance initiatives. To counteract growing antibiotic resistance, Ha et al. (2017) highlighted the need for ongoing surveillance, antimicrobial stewardship, and the creation of innovative treatment approaches [8].

Ceftriaxone resistance in *Escherichia coli* was 100%. Similarly, a study by Sebre et al. (2020) found that *Escherichia coli* had a high level of Ceftriaxone resistance (77.8%). *Escherichia coli* was shown to be very resistant to ceftriaxone (63%) in a study carried out at Comprehensive Specialised Hospital in Mekelle, Northern Ethiopia [41]. The formation of extended-spectrum beta-lactamases (ESBLs), which hydrolyse the beta-lactam ring in ceftriaxone and make the antibiotic ineffective, is probably the cause of Escherichia coli's significant resistance to ceftriaxone. These resistance genes are frequently acquired by ESBL-producing E. coli strains by horizontal gene transfer, which contributes to the general resistance to third-generation cephalosporins like ceftriaxone [42].

The results of this investigation show that bacterial contamination in hospital settings is a significant problem, especially departments such as OPD, surgical and Emergency wards. The predominance of *Staphylococcus aureus*, the existence of gram-negative nosocomial infections and its noteworthy patterns of antibiotic resistance underscore the pressing need for improved infection control measures. To reduce the spread of germs and antibiotic resistance, hospitals must reinforce hygiene

protocols, implement rigorous antimicrobial stewardship programs, and routinely conduct surveillance of nosocomial infections. Continuous monitoring and adherence to best practices will be crucial in reducing hospital-acquired infections and improving patient safety in healthcare settings.

Limitations

While molecular identification methods were not used due to resource limitations, the authors acknowledge that Gram staining and biochemical tests alone may not be sufficient for complete bacterial identificationHowever, methicillin resistance was determined using a methicillin disk rather than cefoxitin, which is currently recommended by CLSI guidelines. Therefore, definitive confirmation of MRSA was not performed, representing a limitation of this study.

LIST OF ABBREVIATIONS/ACRONYMS

NI: Nosocomial infection
HCAIs: Healthcare-associated infections
BSI: Blood stream infection
UTI: Urinary Tract Infection
KIU-TH: Kampala International University-Teaching Hospital
MRSA: Methicillin Resistant Staphylococcus aureus
TSI: Triple Sugar Iron
HAI: Hospital acquired infections
OPD: Out patient department

DECLARATION

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Author contributions

The study was conceived, designed, and carried out by AAA, MCI. Data and sample collection was overseen by AAA, SAO, SHM, FDS, OSU, TP, and DOM; laboratory analyses were performed by AAA, SAO, SHM, DOM, TP, and BB. The data analysis was done by AAA and MAM. The manuscript's initial draft was authored by AAA and MCI, and it was critically evaluated by all authors. The final draft of the work has been reviewed and approved by all authors.

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Conflict of interest

This study declares no competing interest from any of the authors

Data availability

The data sets used and/or analyzed during this study are available from the corresponding author on request.

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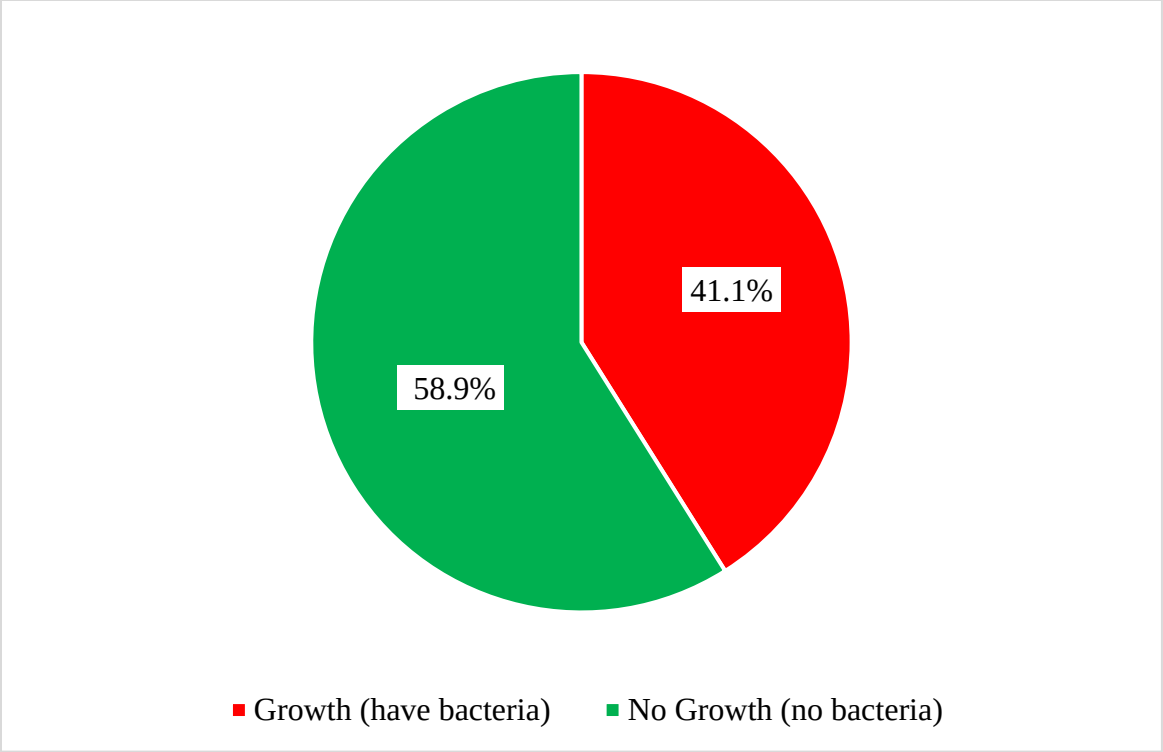

Figure 1: Proportion of hospital material samples that were contaminated with bacteria versus those without bacterial growth at KIU Teaching Hospital (n = 112).

Table 1: Prevalence of bacterial contamination on different hospital material and departments at KIU Teaching Hospital (n = 112).

	Bacterial Growth	
	Growth	**No Growth**
Hospital material		
Doctors' table	6(40%)	9(60%)
Bed	21(47.7%)	23(52.3%)
Surgical tray	4(36.4%)	7(63.6%)
Surgical table	0 (0%)	2(100%)
Trolley	10(30.3%)	23(69.7%)
Wheel chair	5(71.4%)	2(28.6%)
Department		
Outpatient Department	2(66.7%)	1(33.3%)
Accident and Emergency ward	12(66.7%)	6(33.3%)
Accident and emergency theater	1(9.1%)	10(90.9%)
Intensive Care Unit	6(46.2%)	7(53.8%)
Maternity ward	10(43.5%)	13(56.5%)
Surgical Ward	15(53.6%)	13(46.4%)
Main Theater	0(0%)	16(100%)

Table 2: distribution of the bacteria isolates present on Hospital Materials at KIU Teaching Hospital

Bacterial isolate	Frequency, N(47)	Percent
Gram reaction		
Gram negative	10	21.3%
Gram positive	37	78.7%
Bacteria species		
Escherichia coli	5	10.6%
Bacillus species	5	10.6%
Enterobacter species	1	2.1%
Pseudomonas aeruginosa	3	6.4%
Staphylococcus aureus	28	59.6%
Klebsiella species	1	2.1%
Coagulase Negative Staphylococcus	4	8.5%

Table 3: Antibiotic susceptibility patterns of the identified bacteria against different antibiotics at KIU Teaching Hospital (n = 112).

Antibiotics		*Escherichia coli*	*Bacillus spp*	*Enterobacter spp*	*Pseudomonas aeruginosa*	Staphylococcus aureus	*Klebsiella spp*	*CONS*
Amikacin	Resistance	0	0	0	0	5 (4.6%)	0	0
	Sensitive	5(100%)	5(100%)	1(100%)	3(100%)	23 (95.3%)	1(100%)	4 (100%)
Amoxiclav	Resistance	3(60%)	4(80%)	N/A	N/A	16 (57.4%)	N/A	2(50%)
	Sensitive	2(40%)	1(20%)	N/A	N/A	12 (42.6%)	N/A	2(50%)
Gentamicin	Resistance	3(60%)	1 (20%)	N/A	N/A	14 (50%)	N/A	3(75%)
	Sensitive	2(40%)	4(80%)	N/A	N/A	14 (50%)	N/A	1(25%)
Clindamycin	Resistance	N/A	4(80%)	N/A	N/A	26 (92.8%)	N/A	3(75%)
	Sensitive	N/A	1(20%)	N/A	N/A	2(6.2%)	N/A	1(25%)
Vancomycin	Resistance	N/A	0	N/A	N/A	5(17.9%)	N/A	0
	Sensitive	N/A	5(100%)	N/A	N/A	23(82.1%)	N/A	4(100%)
Imipenem	Resistance	0	0	0	0	25(89.3%)	0	4(100%)
	Sensitive	5(100%)	5(100%)	1(100%)	3(100%)	3(10.7%)	1(100%)	0
Ceftriaxone	Resistance	5(100%)	N/A	1(100%)	3(100%)	N/A	1(100%)	N/A
	Sensitive	0	N/A	0	0	N/A	0	N/A
Ciprofloxacin	Resistance	2(40%)	1(20%)	0	0	10(35.7%)	0	N/A
	Sensitive	3(60%)	4(80%)	1(100%)	3(100%)	18(64.3%)	1(100%)	N/A
Methicillin	Resistance	N/A	N/A	N/A	N/A	24(85%)	N/A	3(75%)
	Sensitive	N/A	N/A	N/A	N/A	4(15%)	N/A	1(25%)

Abbreviations: N/A = Not Applicable (isolate not tested with the antibiotic), spps = species, CONS = Coagulase Negative Staphylococcus